# "Hey, I'm learning this."

Leicha A. Bragg explores the thinking and learning involved in playing a decimal fraction game.

Mathematics games are often used in the classroom as a reward or warm-up activity before the "real" learning takes place. Many teachers have witnessed how useful games are for tuning-in students to the impending mathematics lesson. However, have you considered playing games as the central part of the lesson? This article explores the benefits and negative impact of games in the classroom and recommends a calculator game that assisted Year 5 and 6 children to challenge their misconceptions of the multiplication and division of decimals

## The impact of games for teaching mathematics

Teachers generally accept that game-playing is beneficial for students, but, what are these perceived benefits?

Educationalists view games as a pedagogical tool which promotes a positive environment for learning (Dienes, 1963). Games appear also to build positive attitudes (Bragg, 2003) self-esteem, and enhance motivation (Ernest, 1986). Games are also seen as promoting mathematical learning (Bright, Harvey & Wheeler, 1983), social interaction (Bragg, 2006a), mathematical discussion (Ernest, 1986; Oldfield, 1991), and risk taking (Sullivan, 1993).

Conversely, games have also been found to have a negative impact on classroom work when employed in particular ways. A study of primary aged students revealed that in classrooms where games were used as a reward, children were inclined to skim over and disregard the quality of their work in an effort to play games (Baker, Herman & Yeh, 1981).

Utilising games in particular ways has an impact on the effect of games on classroom productivity. Employing games as the main focus of the lesson, and not as a reward for early-finishers, is a method for promoting positive responses towards games. The following study employed games

as the focal point of the mathematics lesson and revealed some positive cognitive results.

## Game-playing trialled in the classroom

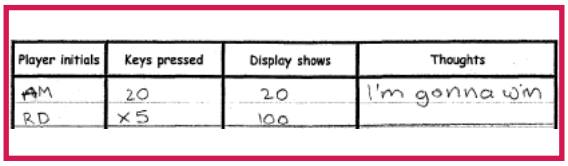
A recent Australian study (Bragg, 2006a) with Year 5 and 6 children (9 to 12 year olds) explored the use of calculator games to assist students in overcoming misconceptions associated with multiplication and division of decimals i.e., specifically multiplication always results in a bigger number, and division always results in a smaller number. It is easy to recognise how this common misconception develops. Often our examples of multiplication illustrate to the student that we always gain "more" when we multiply. Likewise, our examples of division include sharing or reducing larger quantities into smaller parts.

Particular games were selected to promote cognitive conflict in the children to assist in overcoming these misconceptions. Below is a description of Guestimate (Swan, 1996), a game played in this research.

## Guestimate

Guestimate is a calculator game centred on multiplication of whole and decimal numbers (see blackline master of instructions for students at the end of this article). The game's aim is to be the first player to arrive at the target of 100.*** (* indicates decimal places in the number). The numbers right of the decimal point have no impact on the game's target. Therefore, answers of 100, 100.36, and 100.7 are all considered winning results.

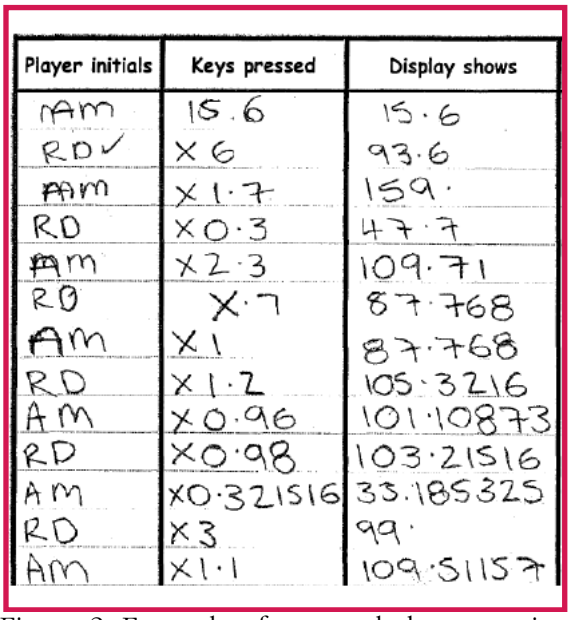
Player one begins by entering a two-digit number. Player two can ONLY multiply this number to attempt to hit the target of 100. The players alternate turns until the target is reached. Each player notes his or her turn on the Guestimate record sheet (see blackline master). The students quickly catch on that inputting an "easy" whole number such as 25 or 50 at the start of the game may result in them losing rapidly as illustrated in Figure 1. Thus, in order to succeed in winning the game, children also realise that the inputting of decimal numbers is required when playing Guestimate.



| Player initials | Keys pressed | Display shows | Thoughts |
|---|---|---|---|
| AM | 20 | 20 | I'm gonna win |
| RD | ×5 | 100 | |

Figure 1: Student choice of starting number

As illustrated in Figure 2 the students readily employed decimal numbers to play the game. This necessity to use decimals during the game is the key aspect in creating cognitive conflict within the students through compelling them to revisit their understanding of multiplication and division. The students' experience of this cognitive conflict is reported below.



| Player initials | Keys pressed | Display shows |
|---|---|---|
| AM | 15.6 | 15.6 |
| RD✓ | ×6 | 93.6 |
| AM | ×1.7 | 159. |
| RD | ×0.3 | 47.7 |
| AM | ×2.3 | 109.71 |
| RD | ×.7 | 87.768 |
| AM | ×1 | 87.768 |
| RD | ×1.2 | 105.3216 |
| AM | ×0.96 | 101.10873 |
| RD | ×0.98 | 103.21516 |
| AM | ×0.321516 | 33.185325 |
| RD | ×3 | 99. |
| AM | ×1.1 | 109.51157 |

Figure 2: Example of a recorded game using decimals

## Students' responses to Guestimate

Guestimate enables students to ponder within the first few turns how to reduce the value of a number greater than the target through the use of multiplication. Interestingly, during interviews with students who played Guestimate there were many positive responses which indicated that the students had grappled with their misconceptions related to decimals. When asked, "Has there been a time during playing the games that you thought, 'Hey, I am learning this?' If so, tell me about it," several children referred to learning

about the effect of multiplication and division of decimal fractions smaller than 1, and referred to strategies they had used; e.g. "Yeah, a couple of times, when I thought, 'Oh, this number gets it down to this and then that number will get it up higher'" (Andrea).

Several children presented more detailed discussion of the problem-solving strategies they used to assist their learning. For example, Frazer said:

> When I played the games I didn't know what it would do if I times it by a point, like just a point and a tenth, or just a whole number and a whole number and a tenth or hundreds or a thousandth. That's what I didn't know. When I experimented with it then I found that point 1 is 10 to the 100 or something. It goes lower than with a whole number and a whole number and a tenth or a hundredth … and with just a whole number would go higher anyway. And, so that's how I learned how to times and what would happen. That's how I knew: that's how I got it first shot, because I learnt how to do it when I was experimenting.

Frazer's initial cognitive conflict was overcome through the use of trial and error, which seems to have helped him develop an understanding of the effect of multiplying decimals and thus he achieved cognitive equilibrium.

The students were also directly asked a question related to their understanding of multiplication: "What can you tell me about what happens when you multiply a number?" Pleasingly, some of the children had developed a true notion of the effect of multiplication after playing the game Guestimate and versions of this game. For example, Coco said:

> If you multiply the number by a full number, for example 26, it will go higher, but if you multiply the number by a decimal, zero point something, it will go lower than the number that you had when you started with the number.

Sandi responded:

> If you times two whole numbers together it gives you a larger number than what you started with. And when you times decimals you get a lower number.

It was clarified that Sandi misused the term "decimal" to mean a number less than 1. The children were able to articulate the effect of multiplication by numbers larger and smaller than one. These comments reveal a development of the students' understanding of multiplication beyond the simplistic notion of numbers becoming larger through multiplication.

Children who replied with a simplistic response such as Sam's, "If you multiply a number it will go higher." were asked a follow-up question: "What can you tell me about what happens when you multiply a number by a number less than one?" All students were able to respond with satisfactory response, such as Sam's, "It will go lower."

Guestimate was also played using only division to assist the children in overcoming a misconception associated with division, i.e. when you divide a number the quotient is always smaller than the dividend. Division and decimals are two concepts with which children often have difficulties. The children were asked, "What can you tell me about what happens when you divide a number?" Pleasingly, in the short space of four weeks, just under a third of the children were able to provide a response that demonstrated some understanding of the effect of division on the quotient. For example Sandi's comment, "When you're dividing a whole number by a whole number the number gets smaller. And when you're dividing decimals it goes higher, I think." As can be witnessed in an examination of Sandi's comment, this student articulated an appropriate response, however, she appeared somewhat unsure if she was correct as her explanation unfolded, i.e. "I think". The children appeared to be beginning to develop an appreciation of the complexity of division involving numbers less than one.

The children who did not provide an accurate response were asked a follow-up question: "What can you tell me about what happens when you divide a number by a number less than one?" The question acted as a prompt for children to revisit their notion of division. Half of the children who were asked the second question were able to articulate the effect of division by a number less than one.

Not surprisingly, half of the children were unable to answer the question or became confused. Norman's response is typical of this confusion.

| | |
|---|---|
| Norman: | Because decimals is like half of it, like 50 divided by 2 is 25. |
| I: | What about dividing by a number less than one? |
| Norman: | It's like the opposite of times. And um, and like if you, yeah… |

Norman stopped talking at this point as he was having difficulty in answering the question. Norman appeared to be aware that dividing a number by less than one does affect the number differently than dividing by a whole number. However, he was unable to articulate what the effect was during the interview.

In summary, it was clear from the responses elicited that the games had given the children the opportunity to question prior misconceptions about multiplication and division. At times the children became confused while attempting to answer the questions. However, this confusion reveals that the students are undergoing cognitive conflict, which, from a constructivist perspective, is a welcome and necessary step for overcoming their mathematical misconceptions (Bragg, 2006b).

## Conclusion

Guestimate deals with quite difficult and challenging concepts for upper primary aged children. However, as witnessed above, the students were able to grasp the complexity of the mathematics involved in the games. The immediate confrontation to the students' mathematical understandings that occurs when playing this game is one of the advantages of Guestimate. The students were also supported through the use of calculators and these appeared to have assisted the process of problem-solving through trial and error. One aspect of the game-playing experience that was particularly pleasing was to witness the students wrestle with their understanding of the mathematics involved in the game and constructed meaning from the problem-solving process. Hopefully, these positive experiences with Guestimate will encourage you to trial this game in your own classroom.

## References


Baker, E. L., Herman, J. L. & Yeh, J. P. (1981). Fun and games: Their contributions to the basic skills instruction in elementary schools. *American Educational Research Journal, 18*(1), 83–92.

Bragg, L. A. (2003). Children's perspectives on mathematics and game playing. In L. Bragg, C. Campbell, G. Herbert & J. Mousley (Eds), *Mathematics Education Research: Innovation, Networking, Opportunity: Proceedings of the 26th Annual Conference of the Mathematics Education Research Group of Australasia, Vol. 1*, (pp. 160–167). Deakin University, Geelong: MERGA.

Bragg, L. A. (2006a). *The Impact of Mathematical Games on Learning, Attitudes, and Behaviours* [unpublished doctoral thesis]. La Trobe University, Bundoora.

Bragg, L. A. (2006b). Students' impressions of the value of games for the learning of mathematics. In J. Novotná, H. Moraová, M. Krátká & N. Stehlíková (Eds), *Proceedings 30th Conference of the International Group for the Psychology of Mathematics Education, Vol. 2*, (pp. 217–224). Prague: PME.

Bright, G. W., Harvey, J. G. & Wheeler, M. M. (1983). Use of a game to instruct on logical reasoning. *School Science and Mathematics, 83*(5), 396–405.

Dienes, Z. P. (1963). *An Experimental Study of Mathematics Learning*. New York: Hutchinson.

Ernest, P. (1986). Games: A rationale for their use in the teaching of mathematics in school. *Mathematics in School, 15*(1), 2–5.

Oldfield, B. J. (1991). Games in the learning of mathematics — Part 1: Classification. *Mathematics in School, 20*(1), 41–43.

Sullivan, P. (1993). Short flexible mathematics games. In J. Mousley & M. Rice (Eds), *Mathematics of Primary Importance* (pp. 211-217). Brunswick, Victoria: The Mathematical Association of Victoria.

Swan, P. (1996). *Kids and Calculators: Using Calculators in the Primary Classroom*. Bunbury, Western Australia: A–Z Type.



Leicha Bragg is a lecturer in the Faculty of Education, Deakin University, Australia.
<leicha.bragg@deakin.edu.au>